

WHAT IS CLAIMED IS:

1. A starting control system for an internal combustion engine comprising:

an electric motor that drives an output shaft of the internal combustion engine so as to be rotated; and

a controller that controls the electric motor to rotate the output shaft in a first direction subsequent to a rotation of the output shaft in a second direction at a predetermined angle upon start of the internal combustion engine, the second direction being reverse to the first direction, and combusts a fuel in a cylinder in an expansion stroke when the electric motor is rotated in the second direction.

2. The starting control system for an internal combustion engine according to claim 1, wherein an intake valve and an exhaust valve of a cylinder in an intake stroke when the electric motor is rotated in the second direction are closed such that the fuel is combusted in the cylinder in the intake stroke.

3. The starting control system for an internal combustion engine according to claim 1, wherein a crank stop position of the output shaft is changed to a predetermined position so as to increase quantity of air in the cylinder in the expansion stroke while the electric motor being rotating in the second direction within a period from a timing after the internal combustion engine is stopped to a timing when the electric motor starts rotating in the second direction.

4. The starting control system for an internal combustion engine according to claim 3, wherein a fuel combustion condition for combusting the fuel in the cylinder in the expansion stroke while the electric motor being rotating in the second direction is obtained based on at least one of the crank stop position of the output shaft that has been changed and a temperature of the internal combustion engine.

5. The starting control system for an internal combustion engine according to claim 4, wherein the fuel combustion condition is obtained based on at least one of quantity of air in the cylinder in the expansion stroke and a temperature of the cylinder obtained from a temperature of a cooling water in the internal combustion engine.

6. The starting control system for an internal combustion engine according to claim 4, wherein the fuel combustion condition comprises a fuel injection quantity and an ignition timing.

7. The starting control system for an internal combustion engine according to claim 1, wherein the controller:

obtains an engine starting torque required for starting the internal combustion engine, and a combustion torque generated in the cylinder in the expansion stroke while the electric motor being rotating in the second direction such
5 that the fuel is combusted therein; and

determines an assist timing at which the electric motor outputs an assist torque to the output shaft based on at least the engine starting torque and the combustion torque such that the assist torque upon rotation of the electric motor in the
10 first direction becomes minimum.

8. The starting control system for an internal combustion engine according to claim 3, wherein when the crank stop position of the output shaft fails to reach an exhaust valve opening position at which the exhaust valve of the cylinder in the expansion stroke while the electric motor being rotating in the second direction
15 starts opening, the crank stop position is changed to a position just before the exhaust valve opening position.

9. The starting control system for an internal combustion engine according to claim 8, wherein a fuel combustion condition for combusting the fuel in the cylinder in the expansion stroke while the electric motor being rotating in the second direction is obtained based on at least one of the crank stop position of the
20 output shaft that has been changed and a temperature of the internal combustion engine.

10. The starting control system for an internal combustion engine according to claim 9, wherein the fuel combustion condition is obtained based on at least one of quantity of air in the cylinder in the expansion stroke and a temperature of the cylinder obtained from a temperature of a cooling water in the internal combustion
25 engine.

11. The starting control system for an internal combustion engine according to claim 9, wherein the fuel combustion condition comprises a fuel injection quantity and an ignition timing.
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12. The starting control system for an internal combustion engine according to claim 9, wherein the controller:

obtains an engine starting torque required for starting the internal combustion engine, and a combustion torque generated in the cylinder in the

expansion stroke while the electric motor being rotating in the second direction such that the fuel is combusted therein; and

determines an assist timing at which the electric motor outputs an assist torque to the output shaft based on at least the engine starting torque and the combustion torque such that the assist torque upon rotation of the electric motor in the first direction becomes minimum.

13. A starting control method for an internal combustion engine in which an electric motor that drives an output shaft of the internal combustion engine is provided so as to be rotated, the method comprising:

controlling the electric motor to rotate the output shaft in a first direction subsequent to a rotation of the output shaft in a second direction at a predetermined angle upon start of the internal combustion engine, the second direction being reverse to the first direction; and

combusting a fuel in a cylinder in an expansion stroke when the electric motor is rotated in the second direction.

14. The starting control method for an internal combustion engine according to claim 13, further comprising closing an intake valve and an exhaust valve of a cylinder in an intake stroke while the electric motor being rotating in the second direction such that the fuel is combusted in the cylinder in the intake stroke.

15. The starting control method for an internal combustion engine according to claim 13, wherein a crank stop position of the output shaft is changed to a predetermined position so as to increase quantity of air in the cylinder in the expansion stroke while the electric motor being rotating in the second direction within a period from a timing after the internal combustion engine is stopped to a timing when the electric motor starts rotating in the second direction.

16. The starting control method for an internal combustion engine according to claim 15, wherein a fuel combustion condition for combusting the fuel in the cylinder in the expansion stroke while the electric motor being rotating in the second direction is obtained based on at least one of the crank stop position of the output shaft that has been changed and a temperature of the internal combustion engine.

17. The starting control method for an internal combustion engine according to claim 13, wherein an engine starting torque required for starting the internal combustion engine is obtained, and a combustion torque generated in the

cylinder in the expansion stroke while the electric motor being rotating in the second direction is obtained such that the fuel is combusted therein; and an assist timing at which the electric motor outputs an assist torque to the output shaft is determined based on at least the engine starting torque and the combustion torque such that the assist torque upon rotation of the electric motor in the first direction becomes minimum.

18. The starting control method for an internal combustion engine according to claim 15, wherein when the crank stop position of the output shaft fails to reach an exhaust valve opening position at which the exhaust valve of the cylinder in the expansion stroke while the electric motor being rotating in the second direction starts opening, the crank stop position is changed to a position just before the exhaust valve opening position.

19. The starting control method for an internal combustion engine according to claim 18, wherein a fuel combustion condition for combusting the fuel in the cylinder in the expansion stroke while the electric motor being rotating in the second direction is obtained based on at least one of the crank stop position of the output shaft that has been changed and a temperature of the internal combustion engine.

20. The starting control method for an internal combustion engine according to claim 19, wherein an engine starting torque required for starting the internal combustion engine is obtained, and a combustion torque generated in the cylinder in the expansion stroke while the electric motor being rotating in the second direction is obtained such that the fuel is combusted therein; and an assist timing at which the electric motor outputs an assist torque to the output shaft is determined based on at least the engine starting torque and the combustion torque such that the assist torque upon rotation of the electric motor in the first direction becomes minimum.